

AIR BAG CRASH INVESTIGATIONS

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ABSTRACT

The performance of air bags, as an occupant protection system, is of high interest to the National Highway Traffic Safety Administration (NHTSA or Agency). Since 1972, the NHTSA has operated a Special Crash Investigations (SCI) program which provides in-depth crash investigation data on new and rapidly changing occupant protection technologies in real world crashes. The Agency uses these in-depth data to evaluate vehicle safety systems and form a basis for rulemaking actions. The data are also used by the automotive industry and other organizations to evaluate the performance of motor vehicle occupant protection systems such as air bags.

This paper presents information from NHTSA’s SCI program concerning crash investigations on air bag equipped vehicles. The paper focus is on data collection and some general findings in air bag crash investigations including: air bag related fatal and life threatening injuries; side air bags; redesigned air bags and advanced air bags.

BACKGROUND

The NHTSA performs research and develops safety programs and standards in an effort to reduce the toll of deaths, injuries, and property damage from traffic crashes. In-depth field investigations on crashes with an air bag deployment are conducted in the SCI program under the auspices of the National Center for Statistics and Analysis (NCSA). SCI cases are an anecdotal data set used to examine and evaluate the latest safety systems. These investigations play a vital role by providing data relative to real world events. The objective of the SCI crash investigation is to provide detailed data for the analysis of air bag deployments. These in-depth investigations include the documentation of crash circumstances, the identification of injury mechanisms, the evaluation of safety countermeasure effectiveness, and the early detection of design and functional problems relative to air bags and vehicle occupants.

SPECIAL CRASH INVESTIGATIONS

The SCI investigators follow up the on-site investigations by interviewing crash victims and other involved parties and by reviewing medical records to determine the nature, cause, and severity of the injuries. Each investigation provides extensive information about pertinent pre-crash, crash, and post-crash events involving the occupants, vehicles, rescue procedures, and environmental factors that may have contributed to the event's occurrence and/or resulting severity. Included in each report are analyses and determinations of occupant kinematics and vehicle dynamics.

From 1972 to 1990, the SCI program investigated all crashes reported to NHTSA that involved an air bag equipped vehicle. However, due to the rapid growth in the number of air bag equipped vehicles present in the marketplace after 1990, the SCI program shifted from investigating all air bag vehicle crashes to investigating only air bag related special interest cases. These cases involve such issues as air bag related serious and fatal injuries, air bag success stories, interaction between air bags and child safety seats, air bag non-deployment crashes, inadvertent air bag deployments, front right passenger air bag performance, side air bag performance, redesigned air bag systems, and the effectiveness of advanced occupant protection systems. These SCI air bag cases have been utilized by the agency and the automotive safety community to acquire knowledge in real world performance of new and emerging air bag systems and have been instrumental in influencing improvements to new generations in air bag technologies.

HISTORY OF AIR BAG FATALITIES

In 1991, the SCI program investigated and confirmed the first allegation of a driver air bag related fatality (CA9109). At that time, the SCI was tasked with locating, investigating, confirming and reporting air bag related life threatening and fatal injury cases. In 1993, the first air bag deployment related child fatality (CA9307) was confirmed. The first air bag related fatality cases were not sampled in the National

Automotive Sampling System (NASS) Crashworthiness Data System (CDS) until 1997.

In 1996, the SCI program was significantly expanded in order to perform investigations of all air bag related life threatening or fatal injuries. In October 1996, NHTSA began publishing summary tables for each confirmed air bag related fatality and seriously injured occupant. The tables are available through the NHTSA website at <http://www.nhtsa.dot.gov/people/ncsa/scireps.html>. These summary tables contain basic information about serious injuries and fatalities related to air bag deployments in low speed crashes to:

- (1) infants in rear facing child safety seats (RFCSS);
- (2) children not in RFCSS;
- (3) drivers; and
- (4) adult passengers

NHTSA has defined children as occupants 12 years of age and under. Serious injury has been defined as a level sufficient to be a threat to life. The injuries that are considered a threat to life have a significant effect on mortality. Low speed crashes have been defined as those with a speed change less than 25 miles per hour.

To be fatally injured by an air bag, the deployment energy of the air bag must be imparted to the occupant. For the deployment energy to be imparted to the occupant, he/she must be in the path of the deploying air bag. In low speed crashes the occupant is most typically out-of-position (OOP) and in the path of a deploying air bag in one of the following two scenarios:

5. The occupant's initial seating position will place them in the air bag deployment path. Initial positioning may include: small or short-stature occupants seated in close proximity to the air bag, as well as occupants that fall asleep, have passed out or are leaning into the air bag deployment path. This scenario includes both belted and unbelted occupants.
6. The occupant is repositioned to a location within the air bag deployment path just prior to deployment by a pre-impact or at-impact event. The event that repositions the occupant into the deployment path includes a number of factors such as: pre-impact braking, multiple closely spaced near deployment events, running off the road or long crash pulses which also result in late

deployments. Unbelted or improperly belted occupants are more likely to become out-of-position in this scenario.

In an effort to create as close to a census of air bag related fatalities as possible in the SCI, the Fatality Analysis Reporting System (FARS) is queried for possible cases. This process is performed annually and has been ongoing since 1992. In 2000, this process was significantly improved. The FARS coding of confirmed air bag related fatality cases was reviewed in an effort to upgrade the criteria used to locate potential cases. A number of additional cases were identified and investigated. As a result, the SCI files contain a near census of low speed air bag related fatalities. Information regarding non-fatal crashes provides valuable engineering information regarding occupant/air bag interactions, however there is no scientific method in place to ensure that these crashes are thoroughly sampled. Since including non-fatal injuries in the calculations could produce risk estimates that are inconsistent with actual trends, only fatality counts were used in these estimates. The SCI continues to monitor the FARS, NASS, law enforcement community and media for potential cases.

SCI cases are divided into two categories unconfirmed and confirmed. Unconfirmed cases are crashes under active investigation where the air bag is suspected of being the injury mechanism. The unconfirmed case fatal counts were initially reported to alleviate a false sense of improvement in declining confirmed case counts. Confirmed case counts typically lag approximately six months from initiation to confirmation. The primary reason for the lag time is medical record acquisition for injured occupants.

For unconfirmed cases, there is always the possibility that the investigation, when completed, will not support a conclusion of an air bag-related injury or fatality. However, since 1997, the SCI headquarters team has pre-screened the notifications submitted. As a result, approximately 90% of the unconfirmed cases are eventually confirmed.

The SCI has confirmed, as of January 1, 2001, 172 air bag related fatalities as noted in Figure 1. One hundred and two air bag related fatalities were children. Eighty three were children not in a rear facing child safety seat (RFCSS), 19 were infants in rear facing child safety seats. There have been 63 adult drivers and 7 adult front right passenger fatalities.

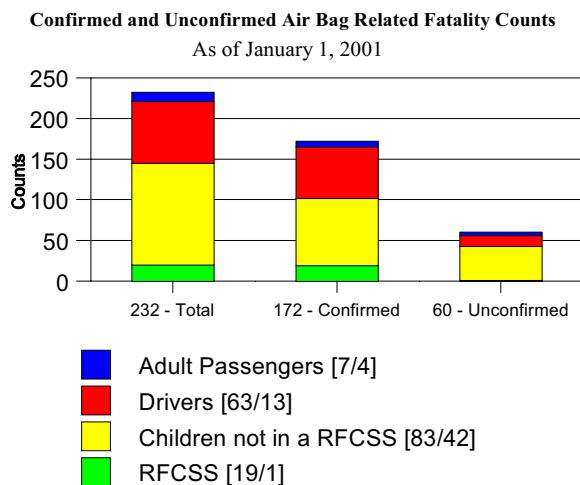


Figure 1. Air Bag Related Fatality Counts by Occupant Type Reported in NHTSA Tables.

Beginning in May 1998, NHTSA began reporting unconfirmed air bag related fatal injury counts in their monthly reports. As of January 1, 2001, NHTSA's SCI program had a total of 232 cases (172 confirmed and 60 unconfirmed) where the deployment of the driver or passenger air bag resulted in a fatal injury to an occupant in a low speed crash.

AIR BAG RELATED CHILD OCCUPANT FATALITIES

Of the 232 fatal cases reported (Figure 1), 145 are children (102 confirmed and 43 unconfirmed). One hundred and twenty five (83 confirmed and 42 unconfirmed) are children not in a RFCSS. Two of the 145 were children who were fatality injured by the driver air bag. Twenty (19 confirmed and 1 unconfirmed) were children in a RFCSS.

Figure 2 presents the data for 12-month production periods for passenger air bags. The data was calculated by dividing the count of children fatally injured by a deploying air bag for each 12-month production period by the total number of registered vehicles with passenger air bags during that same interval. Each 12-month production period was aligned with the vehicle production year, September 1 through August 31.

NHTSA and its partners, (manufacturers, insurance companies and other organizations) have committed a high volume of public education resources in an effort to prevent air bag related injuries and fatalities,

especially to children. This media attention appears to be having a positive effect on reducing child fatality cases. Despite the emergence of more than 15 million vehicles equipped with passenger air bags annually, there has been a significant down trend (see Figure 2) in the air bag related child fatality rate when normalized for vehicles equipped with passenger air bags.

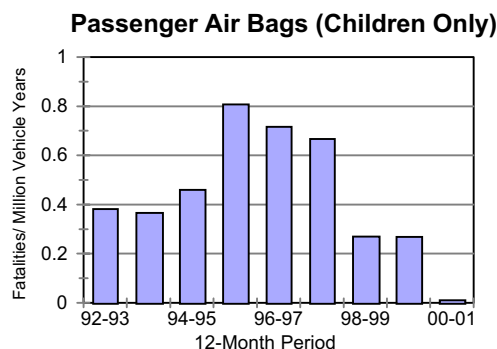


Figure 2. Normalized - Child Fatally Data by 12-Month Vehicle Sales Periods.

NHTSA issued a rulemaking action in March of 1997 that allowed automobile manufacturers to expediently reduce the force at which their air bags deployed. A number of manufacturers began installing these reduced power air bags in their 1998 model year vehicles. NHTSA refers to these reduced power as redesigned air bags.

NHTSA has investigated 10 cases (4 confirmed 6 unconfirmed) where the deployment of a redesigned passenger air bag resulted in a child fatality. In all cases the unbelted child was out-of-position and struck by the deploying redesigned air bag, resulting in a fatal

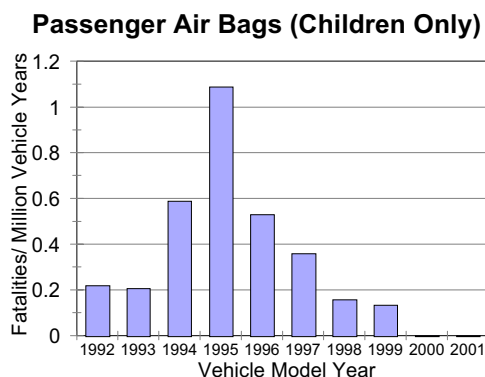


Figure 3. Children Fatally Injured by an Air Bag by Vehicle Model Year

head or neck injury. As of January 1, 2001, NHTSA has not been notified of any crashes involving a 2000 or 2001 model year vehicle where a child passenger air bag related fatality is suspected (see Figure 3.)

CHILD PASSENGER KINEMATICS AND INJURY MECHANISMS

The following provides a discussion of the child passenger kinematics and injury mechanisms associated with front right passenger air bag induced injuries. In all cases, the crash investigators have identified the passenger air bag and/or air bag cover flap as the source of the critical-to-fatal injuries. Little or no intrusion of the occupant compartment was reported, and the cases have a speed changes less than 25 miles per hour. Given the level of the crash severities involved in most of the cases investigated, one would not expect that these children would have sustained life threatening or fatal injuries in the absence of an air bag.

The child air bag problem is most logically broken down into two distinct situations: infants in RFCSS or children not in a RFCSS located in the front right passenger seat position. A discussion of the injury mechanisms for each group are provided below.

Rear-facing Infant Injuries

Of the 20 infant fatalities, 11 were restrained in an appropriate infant seat, and the seat was secured by the seat belt in the front right seating position of a passenger air bag equipped vehicle. However, this is not considered properly restrained, since a RFCSS should never be placed in the front seat of a vehicle equipped with a passenger air bag. The only exception is for vehicles with no back seat that are equipped with an air bag on/off switch.

In the remaining nine cases, three were in RFCSS being held on the lap of the front right occupant and six were either not properly secured in the RFCSS or the RFCSS was not secured with the vehicle's seat belt. In all 20 cases, the vehicle's driver and/or other adult passengers ignored the warning labels located on the sun visor and/or on the child safety seat and placed the infant in the front right seating position.

The crash scenario for air bag involvement with rear-facing infant seats is similar for all cases. Upon impact, the deploying passenger air bag interacts violently with the back of the rear-facing infant seat, typically with sufficient force to crack or break the plastic shell. The force and rapid acceleration of this impact are carried

through the rear facing child safety seat and into the child's head, typically causing skull fractures and associated brain injuries.

Children NOT in a RFCSS Injuries

As noted earlier, there are a total of 125 children, 83 are confirmed and 42 are unconfirmed as fatally injured by a deploying air bag. The confirmed cases contain information on the restraint use and injury information. The two children fatally injured by a deploying driver air bag will be excluded from this analysis. This analysis is based on the 81 confirmed children not in a RFCSS fatally injured by the deploying passenger air bag. With the exception of six, the children were either unrestrained or improperly restrained by the available seat belt system (see Figure 4.)

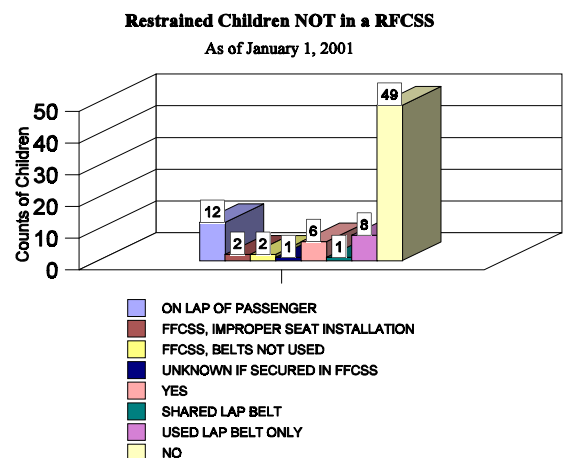


Figure 4. Restraint usage for Confirmed Forward Facing Children Fatally Injured by a Passenger Air Bag

Six children were restrained by the lap and shoulder belts. NHTSA recommends the proper restraint for all children 12 years of age and under is properly restrained in a rear seating position. For Five of the six belted children the proper restraint for their physical dimensions would have been a child safety seat. The sixth child was leaning into the path of the deploying passenger air bag.

Sixty-nine of the 81 fatalities involved pre-impact braking which caused the child to move forward into close proximity of the stored air bag. Occupant contact with the instrument panel prior to deployment has been confirmed for some cases by the identification

of tissue, fluid, and/or clothing transfers on the air bag cover flap and/or instrument panel.

In the vast majority of cases, upon impact, the air bag deploys into the out-of-position child's chest, neck, and face resulting in a rapid translation and extension of the air bag under the chin against the neck and then wrapping upward from ear to ear. The occupant's head is effectively lifted upward off the neck resulting in an atlanto-occipital fracture (C1-C2) and/or a transection of the spinal cord, and/or brain stem injuries. Axonal diffuse brain injuries, consistent with rapid movements of the head are also commonly reported. Skull fractures were typically not observed.

There appears to be a correlation between restraint usage and the injury patterns (see Table 1). When the child passenger has any form of positive indication of restraint usage the head appears to have a higher propensity for injury. When there is no indication of restraint usage the neck appears to be the most likely source of the fatal injury.

Table 1 Children NOT in a RFCSS Passengers Confirmed as Fatally Injured by the Air Bag As of January 1, 2001			
Any Type of Restraint Usage	Head	Head & Neck	Neck
Positive	10	4	3
Negative	17	10	37

In Figure 5, the cumulative percentage of forward facing children indicates the majority of children involved in air bag related fatalities are less than seven years of age.

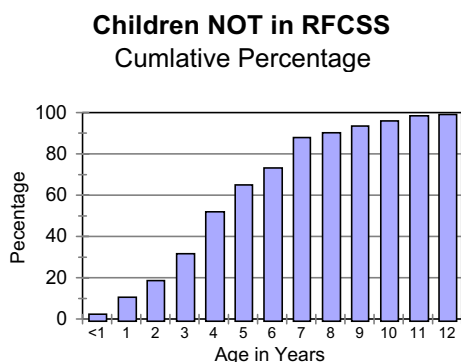


Figure 5. Cumulative Age in Percent of Children Not in a RFCSS.

AIR BAG RELATED ADULT FATALITIES

As of January 1, 2001 the Agency had a total of 87 cases (70 confirmed and 17 unconfirmed) in which the deployment of the driver or passenger air bag resulted in a fatal injury to an adult occupant in a low speed crash (see Table 2). In Table 2 the unconfirmed counts are in brackets.

Table 2
Adults Fatally Injured by the Air Bag
By Crash Year
As of January 1, 2001

YEAR	ADULT DRIVERS	ADULT PASSENGERS	TOTALS
1990	1	0	1
1991	4	0	4
1992	3	0	3
1993	4	0	4
1994	7	0	7
1995	5	0	5
1996	7	2	9
1997	16 [5]	4 [1]	20[6]
1998	10 [1]	0 [2]	10[3]
1999	2 [4]	0	2[4]
2000	4 [3]	1 [1]	5[4]
TOTAL	63[13]	7[4]	70[17]

Figures 6 and 7 present the data for 12-month production periods for adults fatally injured by a driver or passenger air bag. The data were calculated by dividing the count of adults fatally injured by a deploying air bag for each the emergence of more than 15 million vehicles equipped with driver and passenger air bags annually, there has been a significant downward trend (see Figures 7 and 8) in the adult air bag related fatality rate when normalized for vehicles equipped with air bags. 12-month production period by the total number of registered vehicles with driver or passenger air bags during that same interval. Each 12-month production period was aligned with the vehicle production year.

NHTSA and its partners (manufacturers, insurance companies and other organizations) have committed a high volume of public education resources in an effort to prevent air bag related injuries and fatalities, especially to short statured adults. This media attention appears to be having a positive effect on reducing adult driver fatality cases.

Driver Air Bag (Adults Only)
As of January 1, 2001

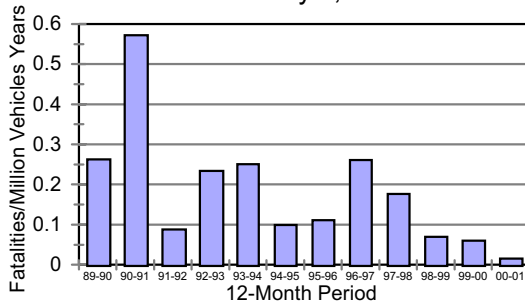


Figure 6. Adult Driver Air Bag Fatalities Normalized by 12-month Vehicle Sales Period.

Passenger Air Bags (Adults Only)
As of January 1, 2001

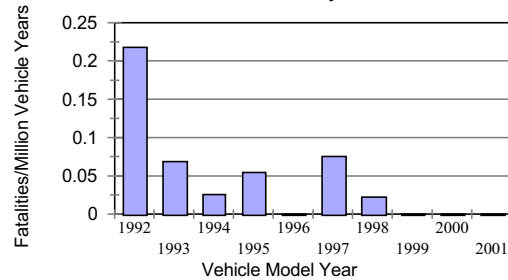


Figure 9. Normalized Adult Passenger Fatally Data by Vehicle Model Year.

Passenger Air Bags (Adults Only)
As of January 1, 2001

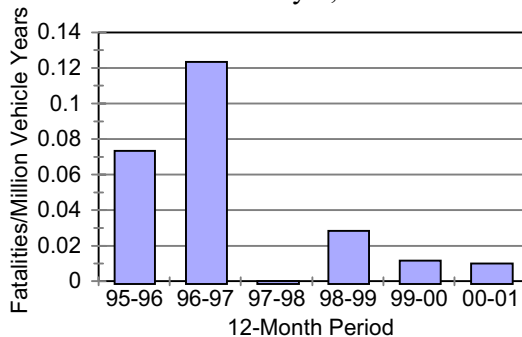


Figure 7. Adult Passenger Air Bag Fatalities Normalized by 12-month Vehicle Sales Period.

Driver Air Bag (Adults)
As of January 1, 2001

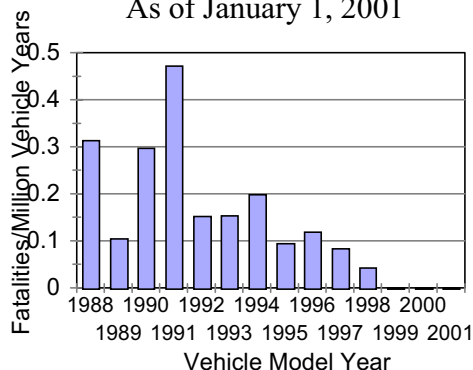


Figure 8. Normalized Adult Driver Fatally Data by Vehicle Model Year.

Figures 8 and 9 present the data for adult air bag related fatalities by vehicle model years for driver and passenger air bags. There has been a general decrease in the fatality rate for the driver and passenger air bag over the last few years; and, as of January 1, 2001, there have been no adult driver or passenger air bag fatalities in model year 1999 vehicles and later.

DRIVER AND ADULT PASSENGER KINEMATICS AND INJURY MECHANISMS

The air bag injury patterns for drivers and adult passengers are uniquely different due to the location, size and shape of the air bags. The driver's air bag, because of its location in the steering wheel hub, is situated in close proximity to the occupant seating position. The front right passenger air bag is typically mounted in the instrument panel and is much larger in size. The larger air bag is needed to fill the space between the instrument panel and the right front passenger and, if present, a front middle passenger.

In all cases, the crash investigators have identified either the driver or passenger air bag and/or air bag cover flap as the source of the fatal injuries. Little to no intrusion of the occupant compartment was reported. Given the level of the crash severities involved, fatal injuries would not be expected.

Adult Driver Injuries

As discussed earlier, to be fatally injured by a driver air bag, the deployment energy of the air bag must be imparted to the out-of-position occupant. Typically, out of position includes small statured occupants seated directly in the path of a deploying air bag or occupants

who become out-of-position into the deployment path during a pre-impact event.

The driver air bag injury patterns are directly affected by the occupants at-deployment positioning in relationship to the body region exposed to the deploying air bag. When the occupant is seated with his or her chest in the deployment path, the most common fatal-to-life threatening injuries include: Multiple bilateral rib fractures, flail chest, lung contusions, fractured sternum, laceration of the myocardium/pericardium, or aorta laceration/tear. In addition, some short stature drivers have received neck extension fractures at the atlanto-occipital joint (fracture at C1-C2) with and without spinal cord involvement. Head injuries are typically diffuse axonal brain injuries, brain stem injuries and basilar skull fractures resulting from rapid acceleration of the head from interaction with the inflating driver air bag.

Table 3 Adults Fatally Injured by the Air Bag By Height and Restraint Usage As of January 1, 2001			
Height in Inches	Any Type of Restraint Usage		Totals
	Positive	Negative/ Unknown	
47		1	1
56		1	1
58	1		
59	1	2	3
60	1	2	3
61	1	2	3
62	4	7	11
63	3	2	5
64	5	8	13
65		5	5
66	1	4	5
67		2	2
68		2	2
69	1		
70		1	1
71		2	2
72	2	1	3
UNK	1		
Total	21	42	63

The 63 confirmed air bag fatality cases contain restraint and injury mechanism information. Twenty-one of the drivers fatally injured by a deploying driver air bag

were either restrained or improperly restrained by the available safety belt system. In all but four of these cases the driver was 64" or less in height (see table 3). NHTSA recommends that drivers keep approximately 10 inches of free space between their breastbone and the air bag.

Driver Air Bag Fatalities by Height
Cumulative Percentage

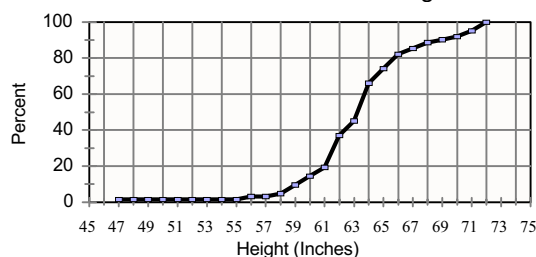


Figure 10. Cumulative Percentage of Confirmed Driver Air Bag Related Fatalities by Height .

In Figure 10, the cumulative percentage of drivers fatally injured by an air bag indicates the majority (80%) are 66 inches or less in height.

Driver Air Bag Fatalities by Age
Cumulative Percentage

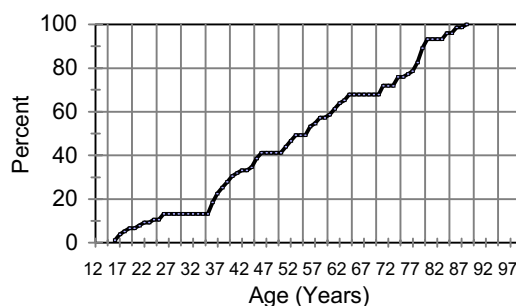


Figure 11. Cumulative Percentage of Adult Drivers in Years

Figure 11, shows the cumulative percentage of adults fatally injured by a deploying driver air bag. Sixty percent of the drivers fatally injured by a deploying driver air bag are over 50 years of age.

Adult Passenger Injuries

The injury patterns for adult passengers are similar to those seen in the forward facing children. The passenger air bags are typically much larger to afford crash protection to the front right occupant. Some of these air bags inflate over an extremely large area in an effort to protect the front middle occupied positions. Typically the front right passenger air bag requires more inflation volume, thereby creating a high potential for injury when an occupant is in close proximity to the air bag

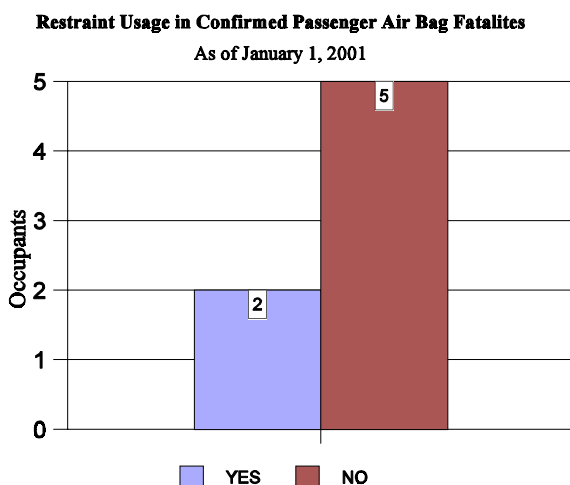


Figure 13. Adults Confirmed as Fatally Injured by a Passenger Air Bag by Restraint Usage.

deployment path.

Adult passenger air bag fatalities are primarily unbelted occupants (see Figure 13). Most are placed out-of-position into the deployment path by a number of factors including pre-impact braking, multiple closely spaced near deployment events, running off the road or long crash pulses which also result in late deployments.

Upon impact, the air bag deploys into the out-of-position adult passenger's neck and head. As the air bag expands, it results in the rapid translation and extension of the air bag under the chin against the neck and then wrapping upward from ear to ear. The occupant's head is effectively lifted upward off the neck resulting in an atlanto-occipital joint fracture (C1-C2) and a transection of the spinal cord, and probable brain stem injuries. Diffuse axonal brain injuries are also commonly reported, but skull fractures were typically not observed. These head injuries are consistent with rapid movements of the head.

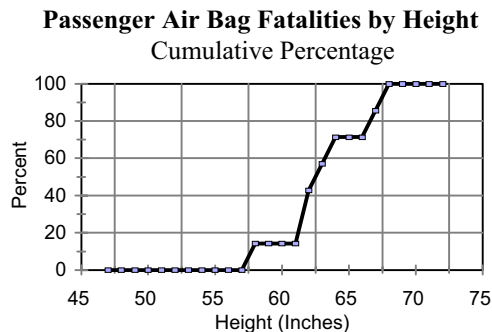


Figure 13. Cumulative Percentage of Confirmed Passenger Air Bag Related Fatalities by Height

In Figure 13, the cumulative percentage of passengers fatally injured by an air bag indicates the majority (71%) are 64 inches or less in height.

In Figure 14, the cumulative percentage of adult passengers fatally injured by a deploying air bag indicates the majority of adults involved are more than 57 years of age.

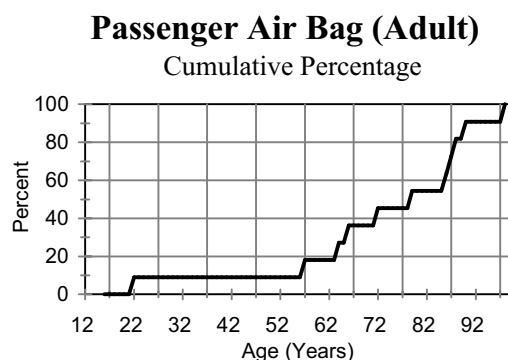


Figure 14. Cumulative Percentage of Adult Passengers in Years

SIDE AIR BAGS

As of January 1, 2001 the SCI has 48 side air bag cases. In February 2000, the side air bag case selection criteria was modified from any crash involving the deployment of a side air bag and/or side curtain to only crashes where one of these devices deployed into an occupied seating position.

Table 4 Number of Cases by Impact Plane As of January 1, 2001	
Impact Plane	Number of Cases
Left	26
Right	11
Rollover	5
Front	4
No Impact	2

As noted in table 4, the distribution of impact planes is as follows: Left side 26 cases, Right side 11 cases, frontal plane four cases, Multiple plane (roll overs) five cases and two cases where there was no impact. The two non impact cases both involved seat mounted mechanical sensors that were activated when a foreign object (a hockey stick and a hand bag) were placed between the door and the side of the seat.

Table 5 Number of Cases by Type of Side Air Bag As of January 1, 2001		
Type of Side Air Bag	Protected Body Region	Number of Cases
Seat mounted	Thorax	22
Door Mounted	Thorax	19
Seat Mounted	Head and Thorax	2
Inflatable Curtain	Head	1
Inflatable Tubular Structure	Head	4

Table 5 includes a case count of the types of side air bags investigated. The majority of the investigations of

side air bags have been for the protection of the thorax only. In all cases the air bag provided an increase in occupant protection. However, most noteworthy was the occupant protection noted in the seven cases with head protection, including at least one fatality due to a thorax injury, no reported life threatening head injuries.

There are 10 drivers and three right front passengers with an injury code of AIS-3 or higher. All but one of these injuries have been attributed to an interior component, the ground or the other vehicle due to a high impact speed, ejection or massive intrusion into the occupant compartment. In the single exception, the driver received an AIS-3 thorax injury attributed to the air bag cover flap in a door mounted thorax air bag system.

REDESIGNED AIR BAGS

In March of 1997, NHTSA issued a rulemaking action that allowed automobile manufacturers to reduce the force at which their air bags deployed. Most of the manufacturers began introducing redesigned air bags into their fleets beginning with 1998 model year vehicles. In order to determine how changes in the air bag affected occupants in real world crashes the NCSA initiated the Redesigned Air Bag Special Study (RABSS) in October, 1997 to collect data on crashes involving these redesigned air bags.

The objective of this study was to collect data on crashes of high interest (children, out of position occupants, high damage severity, and multiple injured occupants) involving vehicles equipped with a redesigned air bag system in which the air bag has deployed.

As of January 1, 2001, the RABSS has a total of 472 cases. Of these 472 cases, 100 are still under active investigation, 131 are undergoing an agency review process and 237 are available to the public. Also included in the reporting system for redesigned air bags are 178 cases listed as PARTNERS cases. These cases are provided by the manufacturers, insurance companies and other organizations.

From October 1997 to January 1998, the SCI was selecting any case with a redesigned air bag deployment, requiring the screening of thousands of police crash reports involving 1998 and newer vehicle. However due to the overwhelming volume of cases and limited resources available, In January 1998, a minimum case selection criteria for inclusion in the study was

initiated. The case selection used from January 1998 to January 2000 was based on a minimum criteria and their interest to NHTSA. All cases that met the minimum criteria were reviewed, however only cases that met a selection factor based on their interest to NHTSA were selected. The following is the minimum criteria and NHTSA interest priority list:

Minimum Criteria for RABSS Selection

- 1998 model year vehicle equipped with a redesigned air bag.
- The crash configuration must be an impact where the air bag is designed to protect the occupants (e.g. 11 to 1 o'clock PDOF). Do not include side or back plane impacts. In addition, exclude rollovers with or without ejection.
- The 1998 model year vehicle must have a complete exterior and interior vehicle inspection and be towed due to damage.
- An occupant must be seated in a position in which a redesigned air bag has deployed.

If minimum criteria is met, then select cases were selected based on their interest to NHTSA in the following priority order.

1. A child under 13 years old is seated in a position with a redesigned air bag deployment.
2. An occupant protected by a deploying redesigned air bag receives fatal injuries.
3. The driver and/or front right occupant protected by a deploying redesigned air bag that are transported to a medical facility for treatment of injuries.
4. Crashes of high severity, regardless of the injury level. These include crashes where the delta V would be greater than 24 MPH. These may be identified by specific information on the police traffic crash report.

From July 1998 to December 1999 the NASS CDS selected redesigned air bag cases out-of-sample. These cases are anecdotal only (not weighted) and have an 800 series case number.

In an effort to focus the redesigned air bag investigations toward true case of interest to the Agency, the following case selection criteria has been established for cases selected after January 2000:

- The crash configuration is a frontal and a child is in a seat position where a redesigned air bag has deployed.
- The crash configuration is a frontal, is not a

rollover and an adult in a seat position protected by a redesigned air bag receives fatal injuries.

- Any crash involving a 2000 model year or newer passenger car or light truck equipped with "smart" or advanced air bag system. These systems include but are not limited to multi-stage inflators, systems with the capability to detect out of position occupants etc.
- Any crash involving a 2000 model year or newer passenger car or light truck equipped with an Event Data Recording device and a deployed driver or passenger redesigned air bag.

NHTSA is currently analyzing this data to determine the effectiveness of redesigned air bags in real world crashes. The conclusions from this data analysis will be published by the Agency at a later date.

ADVANCED OCCUPANT PROTECTION

In May 2000, an interim final rule for FMVSS No. 208 was issued by NHTSA that amends the occupant crash protection standard to require that future air bags be designed to create less risk of serious air bag-induced injuries than current air bags, particularly for small women and young children; and provide improved frontal crash protection for all occupants, by means that include advanced air bag technology. To achieve these goals, it adds a wide variety of new requirements, test procedures, and injury criteria, using an assortment of new dummies. It replaces the sled test with a rigid barrier crash test for assessing the protection of unbelted occupants.

The interim final rule is also a performance based standard that does require manufacturers to specifically incorporate advanced sensors, inflators, or suppression technologies.

A few automobile manufacturers began introducing advanced occupant protection systems into their fleets beginning with 2000 model year vehicles. In an effort to determine how changes in the occupant protection systems affected occupants in real world crashes the NHTSA initiated the Advanced Occupant Protection Special Study (AOPSS) in September, 1999 to collect data on crashes involving 2000 model year vehicles equipped with advanced occupant protection systems.

The objective of the AOPSS is to provide data that will assess the real world performance of new occupant protection technologies. For this study, advanced occupant protection may include one or more of the following: seat belt sensors, weight sensors, seat position sensors, multi-stage inflators, systems that may provide automatic air bag suppression, rollover sensors and event data recorders.

Due to the few number of vehicles currently available with an advanced occupant protection system the case selection criteria has been very general. Also because the air bag deployment thresholds have been significantly raised, air bag deployment is no longer considered. The minimum criteria for AOPSS case selection are:

1. >2000 model year vehicle equipped with an advanced occupant protection system.
- The crash configuration must be an impact where the advanced restraint system is designed to protect the occupants and the vehicle is towed due to damage
- Back plane impacts and rollovers are excluded
- Side impact crashes are included only if the vehicle is equipped with inflatable side impact protection and that protection deployed into a occupied seating position

As of January 1, 2001 the AOPSS program has a total of 35 cases. Thirty-one cases are still being actively investigated. Four have been submitted for agency review. The Agency will begin publishing tables with the advanced occupant protection system data in 2001.

The Agency is sharing the field data with the automobile manufacturers regarding the technology surrounding these new occupant protection devices. This collaborative effort combines the talents of crash investigators, engineers, and designers, which enable all interested parties to perform case-by-case evaluation of the real world performance of these advanced technologies. Particularly noteworthy is the technical analysis of the event data recorder (EDR) output . The EDR data has provided invaluable information relating to occupant status, severity assessment, and deployment control in researching crashes with advanced occupant protection systems.

CONCLUSIONS

NHTSA and its partners, (manufacturers, insurance companies and other organizations) have committed a high volume of public education resources in an effort to

prevent air bag related injuries and fatalities, especially to children. This media attention appears to be having a positive effect on reducing child fatality cases.

NHTSA's rulemaking changes beginning in March of 1997 have had a positive effect on reducing air bag related fatalities. As of January 1, 2001, there have been no adult driver or adult passenger air bag fatalities in 1999 and newer model year vehicles. In addition, there have been no 2000 or 2001 model year vehicles involved in a child passenger air bag related fatality. However, the SCI program will continue to monitor, confirm and report air bag related fatality data.

In all crashes investigated with a side air bag deployment, the air bag provided an increase in occupant protection. Most noteworthy is that in the seven cases with head protection, including at least one fatality due to a thorax injury, there have been no life threatening head injuries reported.

AIR BAG CRASH INVESTIGATION DATA AVAILABILITY

The NHTSA has a number of methods in which the air bag crash data is distributed. Beginning in 2001, summary tables will be published quarterly on the National Highway Traffic Safety Administration's (NHTSA) Internet web site at the following web address:

<http://www.nhtsa.dot.gov/people/ncsa/sci.html>

Copies of the summary tables can also be obtained by calling one of the following telephone numbers and requesting "Air Bag Fatality Reports for Special Crash Investigations"

Toll Free 800-934-8517
Local Number 202-366-4198

Special Crash Investigations cases will be available from the National Automotive Sampling System's web page beginning June 2001.

<Http://www-nass.nhtsa.dot.gov/nass>

Copies of completed hard copy SCI reports listed as available on the summary tables can be obtained at the address below. The reports contain images and accordingly there is a cost associated with reproduction of the crash report.

Marjorie Saccoccio, DTS-44
DOT/Volpe National Transportation Systems Center
Kendall Square
Cambridge, MA 02142
USA

Completed SCI reports can be reviewed at the hard copy storage facility. There is a nominal cost for case retrieval and handling.

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REFERENCES

1. "Selecting and Using the Most Appropriate Car Safety Seats for Growing Children: Guidelines for Counseling Parents", Pediatrics Volume 97 No 5 May 1996, American Academy of Pediatrics, Committee on Injury and Poison Prevention
2. "Monthly Counts for Air Bag Related Fatalities and Seriously Injured Persons", January 2001, Special Crash Investigation, U. S. Department of Transportation, National Highway Traffic Safety Administration
3. "Redesigned Air Bag Summary", January 2001, Special Crash Investigation, U. S. Department of Transportation, National Highway Traffic Safety Administration
4. "Side Air Bag Summary", January 2001, Special Crash Investigation, U. S. Department of Transportation, National Highway Traffic Safety Administration
5. "Advanced Air Bag Summary", January 2001, Special Crash Investigation, U. S. Department of Transportation, National Highway Traffic Safety Administration
6. "Air Bag Crash Investigations", Chidester, Augustus., U. S. Department of Transportation, National Highway Traffic Safety Administration